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Precision Agriculture Use In Management And Correction In Soil Heveiculture

Utilização Da Agricultura De Precisão Na Gestão E Correção Do Solo Na Heveicultura

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Abstract
The rubber of Culture with a quality soil remediation management best expresses its characteristics responding in productivity. The cultivation of Hevea brasiliensis gender different from other cultures does not cover the fruit, but rather the latex, which is extracted from the plant stem. As the procedures are delicate, it requires technical knowledge of the process, so you need tools that help in precision and accuracy, and this process needs to be deployed in establishing the culture at the base, ie, soil correction, which conditions this environment for the best plant expressions in the production environment. This need to enter the technological tools of precision agriculture applications applied the culture of rubber trees, a tool that has a lot to contribute in the forest production sector. The application of technology has been fully carried out taking into account the reality of the rubber cultivation sector with a tool that assists in the management of processes for tasks that represent trays which in turn are sampled and interpolated for purposes of recommendations and preparation of thematic correction maps soil, and knowledge of the variability of soil characteristics.

Resumo
A cultura da seringueira com um manejo de correção do solo de qualidade expressa melhor suas características respondendo em produtividades. O cultivo do gênero Hevea brasiliensis diferentes de outras culturas não visa os frutos, mais sim o látex, que é extraído do tronco da planta. Como os procedimentos são delicados, exige-se conhecimento técnico do processo, assim, é preciso ferramentas que auxiliem na precisão e acurácia, e este processo precisa ser implantado no estabelecimento da cultura, na base, ou seja, na correção do solo, que condiciona este ambiente para as melhores expressões da planta no ambiente de produção. Nesta necessidade que entra a aplicações de ferramentas tecnológicas da agricultura de precisão aplicadas a cultura da seringueira, uma ferramenta que tem muito a contribuir no setor de produção de florestas. A aplicação da tecnologia foi totalmente realizada levando em consideração a realidade do setor da heveicultura, com uma ferramenta que auxilia na gestão dos processos por tarefas que representam tabuleiros que por sua vez são amostradas e interpoladas para fins de recomendações e confecção de mapas temáticos de correção do solo, e o conhecimento de características da variabilidade do solo.

INTRODUCTION

The rubber tree culture belongs to the Euphorbiaceae family, with it is natural occurrence in the Brazilian Amazon and in most of the South American countries (Secco, 2008). The rubber tree belongs to the genus *Hevea*, with which 11 species are cultivated, where the most used is the species *Hevea brasiliensis*. The species *Hevea brasiliensis* (Willd. Ex Adr. De Juss.) Muell. Arg., Is the most used for commercial exploitation, due to the quality and quantity of latex it produces (Gonçalves & Fontes, 2009). This natural rubber is a hydrocarbon whose chemical formula is a poly (cis-1,4-isoprene) polyme (Rippel & Bragança, 2009).

Brazil owns only 1% of world rubber production, behind countries like Thailand with 36% of production, Indonesia with 22%, Malaysia 12%, China representing 9% and India with 6% of the world production of the tree. However, these countries that produce the most are already under limited expansion, while Brazil still has areas with capacity for development in the sector (Martins, 2012).

Natural rubber is a natural polymer extracted from the sap of the rubber tree (Matos et al., 2017). Due to its economic importance, natural rubber is a strategic raw material for more than 50,000 products, including pneumatic and medical products such as prostheses (Van Beilen & Poirier, 2007), Area of nanotechnology, and will allow new inventions to become reality (Rippel & Galembeck, 2009). In addition, the rubber tree also contributes its wood, which is qualified as an excellent raw material for the furniture segment, especially for residential furniture, office furniture, lining and stairs (Kronka, 2008).

The correction of the soil is one of the primordial factors for a good productivity of the cultures, not only in the agricultural years, but also in the successive years (Alovisi et al., 2018), and to answers to manurings, mainly in soil of savannahs where be acid, and most of the time it possesses a great amount of Aluminum (Al), that it is poisonous for the plant, and it can still be economically one of the main ones responsible for the bass acting of plants important in acid soils (Echart & Cavalli-Molina, 2001).

The rubber tree has certain demand of correction of the soil in the savannah, and in spite of being a culture that possesses certain rusticity in the toxicity of aluminum, with effects caused in the cells, the alteration of the biological membranes, inhibition of the (Cupertino et al., 2016), who can commit the initial development of the culture, influencing his / her productive potential after the production period (Carmo et al., 2002).

Like this, the liming in the rubber plantation aids of the development of the so much culture of the I begin of the cultivation as in the productive stadium, in spite of to be in tolerant parts the acidity and to present good production in soils with saturation of bases above 30%, the savannah soils most of the time, it provides a high acidity, and low saturation of bases. Therefore, it is recommended before the planting, the application of way limestone to elevate the saturation for bases for 50%, to promote a good relationship among law of the maximum, minimum, and toxicity of the plant (Gonçalves et al., 2013).

The Agriculture of Precision (it is also denominated "Precision Farming", "Precision Agriculture" and "Site Specific Crop Management") is an administration system that appeared with that aim at. This growth was improved for technological progress involving, the system of global (SPG or GPS) positioning, remote sensing, application of inputs in variable taxes, system of geographical (SIG or GIS) information, among others. Those technological products make possible to visualize and to handle the agricultural area in agreement with the space and temporary variability of the edaphic factors, differently than it was possible until then, when the area was considered uniform and, therefore, handled as such (Pires et al., 2004).

According Honda & Jorge (2013), they emphasize that through the information obtained by the specialist systems the farmer can map and to accomplish the handling of the cultivation and of the lands in having owed proportions of inputs in each unit of the field, in a more intelligent and effective way. It is treated of the use of techniques of digital processing of images and artificial intelligence, that they are used to accomplish all of the artifices in the captured images, in order to generate satisfactory implications for the visualization.

Precision agriculture (PA) in all its features is a tool of extreme importance for all levels of production, where it acts directly in the processes related to production, and economic factors, the characterization of the spatial variability of attributes of the soil and crops, maximizes agricultural processes by generating savings and improving decision making by making them more assertive, providing more accurate management and precision (Bellé, 2009).

It can be Oliveira et al. (2008) and Bernardi et al. (2017), which with the application of fertilizers and correctives at variable rates based on precision agriculture provides a great alternative to enhance the productive process and also reduce the impact of agricultural activity on the environment. Resende et al. (2014) reported the large growth of geo-referenced samplings for the generation of soil fertility maps and the distribution of correctives and fertilizers at variable rates. This importance can be ensured by the greater efficiency in the use of inputs in precision agriculture with a greater level of detail than in conventional agriculture, where the samples are randomly withdrawn and their recommendations based on the average of the results found (Weirich Neto et al., 2006; Barbieri et al., 2008).

The objective of this work was to use precision farming techniques to raise the spatial characteristics of soil variability, making the recommendations according to the need to correct the soil of each task, to use the thematic maps of soil variability to obtain a cost analysis for correction.

MATERIAL AND METHODS

This work was carried out during two years of harvest, accompanying the crops of 12/13 and 13/14, in the production of latex, in the culture of heveculture. The activities were carried out in partnership with the company Goiás Látex, located in the municipality of Goianésia-Goiás, latitude -15.286550º and longitude -48.858547º, altitude at 620 m, where the work of soil correction was carried out using AP methods, application at varied rates, to the technologies for carrying out the activities and carrying out the activities, several criteria were observed as a nutritional requirement of the plant, in order to observe the importance in the soil correction quality.

In the procedure was used a system of soil sampling by composite points, using a georeferenced grid, with a density of 1 point every 5 ha, 0-20 cm depth, and 1 point every 10 ha at 0- 20 and 20-40, after generating a shapefile, using the GPS trackmaker program, to import the GPS etrex 20 sampling points, for field sampling by traversing the points in order to sample the points locations, assigning the respective analysis values to the table of point attributes, samples were taken for identification of samples, samples were collected and samples were collected, polyethylene bags were used for the storage of the samples, also labeled with the identifications that were already made printed on the sampling report, on the grid map from the office to the field (Oliveira et al., 2008).

The samples were taken between rows and lines, so as not to overestimate the amount of nutrients due to the application of product in the planting lines, at each sampling point, another 6 sub-samples were removed in a radius of 20 m² from the georeferenced point, aiming at to eliminate the spatial error, the contour of the area was performed with RTK, in order to obtain a greater precision and representativeness of the ground, the following items were analyzed in laboratory: (MO, P resin, K, Ca++, Mg^{2+}, Al^{3+}, H^{3+}, Al, Ph, Ca/Mg, CTC T, m%, V%, Arg, S), (Ribeiro et al., 1999).

For the conduction of the work samples of the following tasks were performed for the experiment, which are available in Table 01.

Table 1. Table with tasks and clones with the number of trees in production.

ASSIGNMENT	CLONE	TREES IN BLEEDING
1	RRIM600	1519
2	RRIM600	1640
3	RRIM600	1708
5	PB235	1794
6	PB235	1580
9	PB235	1755
10	PB235	1778
13	PB217	1543
15	GT1	1253
19	RRIM600	1481
20	RRIM600	1643
22	RRIM600	1806
30	RRIM600	1637
37	RRIM600	1233
45	RRIM600	1664
46	RRIM600	1626
47	RRIM600	1517

The identified and sealed samples were delivered to Jalles Machado's laboratory for soil analysis. The clones that are involved in the works are: RRIM600, PR255, GT1, PB217, the evaluations of the works were carried out in the tasks mentioned in Table 02.

After the analyzed samples, the results were observed, and the data interpolation was carried out to generate the recommendations of soil correction, with the application of limestone, the geostatistical method of kriging.

The kriging method is one of the only interpolation methods that sets the model for a spatial variance behavior of the raw data and uses this model to estimate the attribute values at points in a regular grid (Varella, 2009). Kriging interpolation is a geostatistical method (Fernandes et al., 2017). This is a very adequate tool to measure spatial dependence, the semivariogram is defined as the mathematical hope of the square of the difference between pairs of a candle variance in space, given by the equation described by Camargo (1998):

$$2\hat{\gamma}(\mathbf{h}) = \frac{1}{N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} [z(\mathbf{x}_i) - z(\mathbf{x}_i + \mathbf{h})]^2 \quad ,$$

Wherein:

- $2\hat{y}(\mathbf{h})$- is the estimated variogram;

- N(**h**) - is the number of pairs of measured values, z($\mathbf{x}_i$) and z($\mathbf{x}_i$+**h**), separated by a distance vector **h**;
- z(x**i**) and z($\mathbf{x}_i$+**h**), - values of the i-th observation of the regionalized variable, collected at points $\mathbf{x}_i$ and $\mathbf{x}_i$+**h** (i = 1, ..., n), separated by vector **h**

The interpolations of the analysis data were performed in a precision agriculture software called InCeres Ag system, where layouts were made to facilitate decision making and to verify the spatial distribution of soil variation. After the layouts, the shape files were also made for field use in a regular grid of 20 m² with a point density of 1 point for every 5 hectares.

Where a recommendation is obtained with the coordinates and the values of the attributes, however, as the rubber culture influences the satellite signal a lot, it interferes with the activities of the corrective truck, "*Hercules Stara*", the technique adopted was the use of the tasks, such as trays, and each task its later its respective recommendation, being able to have an application in varied rate, by trays, or tasks. This technique allows the application and use of the variable rate, also for small producers who do not have high technologies to perform this work, also allowing the use of the division of tasks that has from 1,500 to 1,700 trees, assisting in nutritional management by task, and not average of the farm recommendation, or in the seringal case.

The application of the limestone was carried out with the recommendation by task, after which the standard procedures of the company were carried out as fertilization, phytosanitary management, taking care that none of the treatments interfered in the correction and the experimental area. This treatment was carried out on 06/03/2013 and evaluated the closure of productivity on 12/20/2014.

In order to adapt the productivity results of the tasks, the following methodology was used:

$$\text{Kg/tree/year} = \frac{N*P}{A}$$

Wherein:

N= Number of boxes per job;

P= Standard average weight per carton;

A = Trees by task;

Kg/tree/year = Kilograms per tree per year.

Magnesium limestone, PRNT of 90 %.

The economic data were taken considering the cost of the product in order to estimate the economy with the technique that was used based on the average recommendation that would be applied. In this case defined in 2000 kg/ha of limestone.

RESULTS AND DISCUSSION

The values of the nutrients found were demonstrated in a practical way with layouts, with the relevant recommendations and the content of the analysis results, making possible the future decisions of the office for the field.

In the aspect referring to the use of the technology the concepts are observed and the results have been presented. Figures 1 and 2 show the spatial distribution of soil organic matter (OM) in the evaluated tasks.

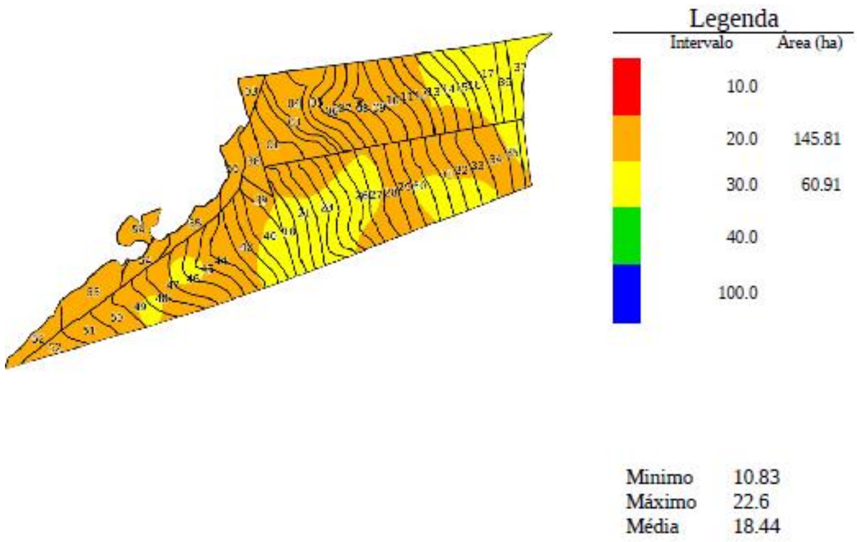

Figure 1. Map representing the distribution of the organic matter content in depth 0-20, in the year 2013.

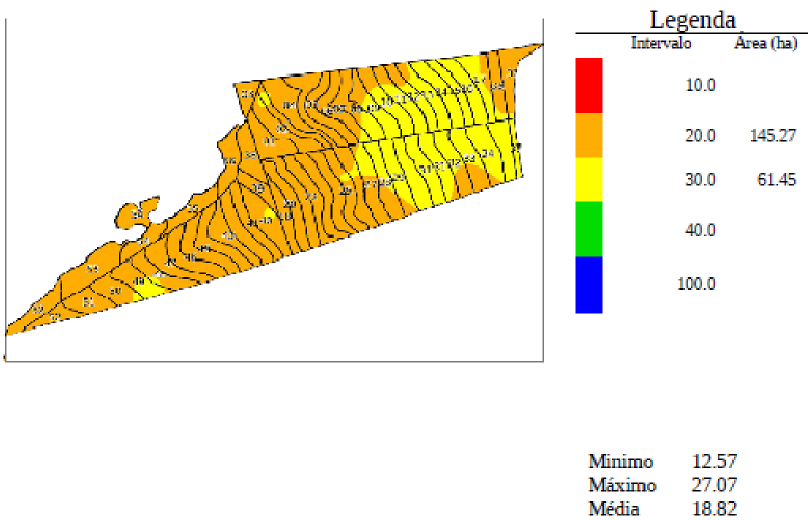

Figure 2. Map representing the distribution of the organic matter content in depth of 0-20, in the year 2014.

The OM maps (organic matter) of 2013 and 2014 demonstrate the distribution of MO levels in the rubber tree, with the representation of the legends that inform the amount of OM content in the soil.

It is possible to analyze the differences in the behavior of OM in the soil, one year related to another, and the relation of map by map, and how the rubber tree is a crop that in a drier period of the year, passes through senescence, which increases even more the variation of OM in the year soil, it is possible to evaluate in Figures 01 and 02, the behavior and variability is observed, being able to verify that the minimum organic matter contents in the year of 2014 were higher than in relation to 2013, where the minimum OM was 10.87 g/kg, the maximum was 18.44 g/kg and the mean was 22.6 g/kg, according to Silva et al. (2009), the residual nutrient content of organic matter is associated with litter decomposition and plant residue variation.

In 2014, the behavior of the variability was not very expressive, but it is possible to verify that the minimum content was 12.57 g/kg, the maximum of 27.07 g/kg and the average of 18.82 g/kg. This result was concomitant with that of Santos et al., (2015), with averages of 18 and 21 g/kg, and Prezotti et al., (2007) found averages of 15 to 30 g/kg on a 0-20 cm surface, however Lima et al., (2008) found values of 25 and 26 g/kg in natural vegetation area under regeneration and grazing conditions. Thus, according to Costa et al., (2013), the OM content may influence the chemical characteristics of the soil due to its direct and indirect effects, so the OM exerts a strong influence on the productive capacity of the soil.

Figures 3 and 4 show the spatial distribution of the Magnesium (Mg) content of Soil in the evaluated tasks. Magnesium is an ion that plays an important role in chlorophyll synthesis, and has great importance in the metabolic processes of a plant. In his work, Filho et al., (2002) concluded that the lower growth of the Fx 567 and Fx 2261 clones seems to be related to the low Ca and Mg contents, sum and base saturation in soils, together with low N, K, Ca, Cu, and B foliar. In order to maintain the optimum levels of this Mg molecule in the soil, in Figures 04 and 05, it is possible to analyze the Mg levels in soil variability. that in 2013 the minimum content of Mg found in the soil was 0.14 cmol/dm³, the maximum content was 2.03 cmol/dm³ and the average was 1.14 cmol/dm³. It is possible to observe a variability of the magnesium in the total area, indicating that the Mg content is not balanced, in 2014 it was possible to verify these levels, although they were lower, it hears a uniformity of the levels in the soil variability, proving that the Mg in which was being applied at a flat rate of 2000 kg/ha, was badly distributed by depositing in excess in certain places, and lacking in others.

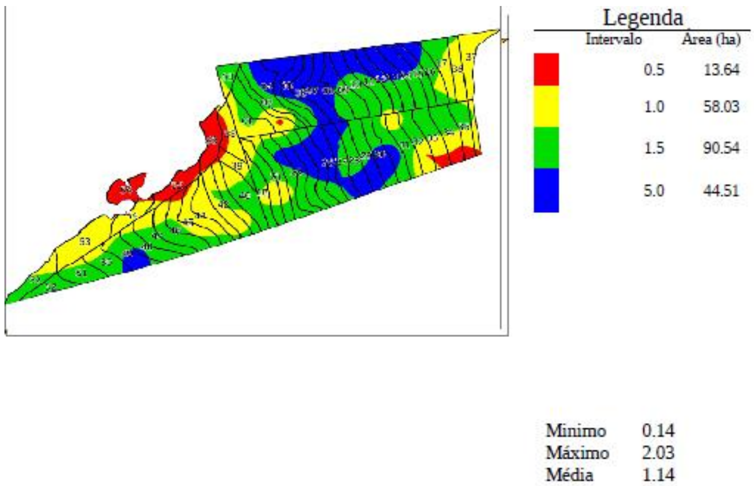

Figure 3. Map representing the distribution of the potassium content in depth 0-20, in the year 2013.

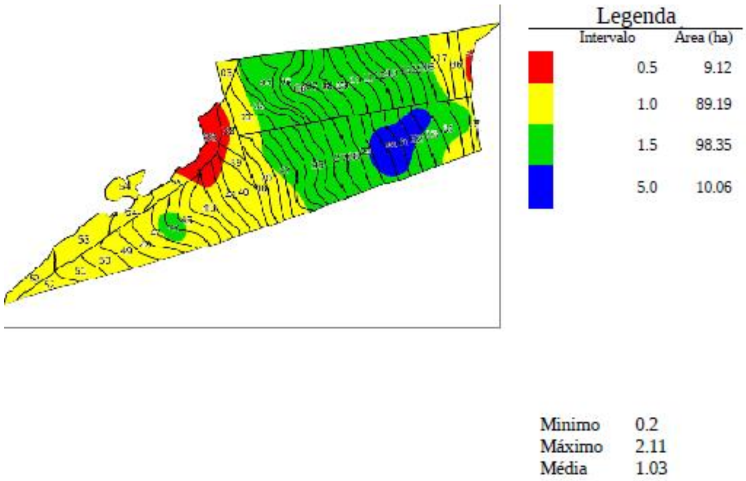

Figure 4. Map representing the distribution of potassium content in the 0-20 depth, in the year 2014.

In this study, the use of potassic fertilizer technology is the fact that the main minerals associated with K availability in Brazilian soils are potassic feldspars, micas, vermiculites and smectites (Curi et al., 2005; Teixeira et al., 2012), besides being a mineral that needs a very assertive management, due to the high price of mineral fertilizers in the market.

It can be observed in the distribution of K in the two years 2013 and 2014, Figure 05 and Figure 06. Where in 2013 the minimum content and of 0.07 cmolc/dm3, already the maximum result found was of 0.061 cmolc/dm3, being the average of 0.61 cmolc/dm3, already in 2014, the results show the minimum of 0.16 cmolc/dm3, being the maximum of 0.73 cmolc/dm3 and the average of 0.33 cmolc/dm^3. The increase in K levels in the year 2014 is explained by the better soil correction and the product is more available to the plant due to the correct handling with precision agriculture and the standardization of the limestone distribution in the area avoiding competition in the relation K/Mg.

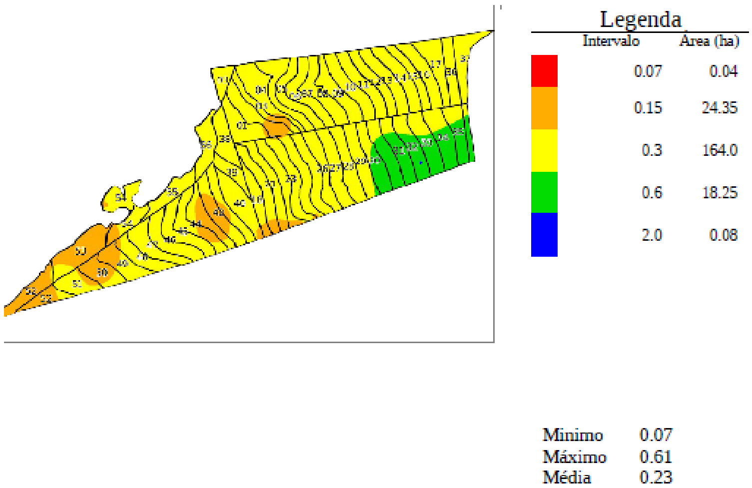

Figure 5. Map representing the distribution of magnesium content in the depth of 0-20 in the year 2013.

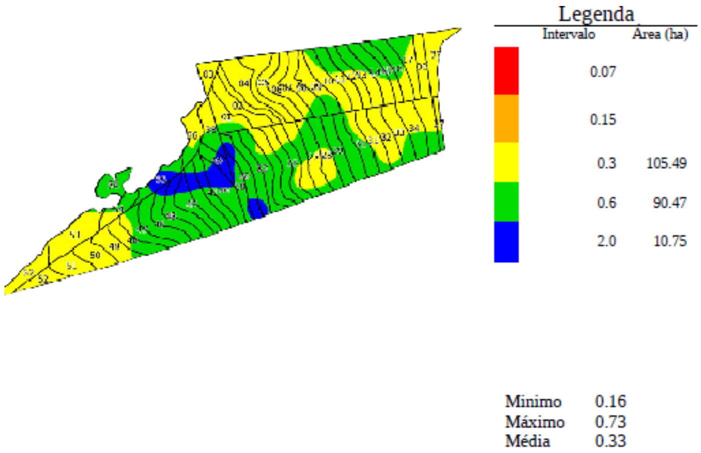

Figure 6. Map representing the distribution of the magnesium content in depth of 0-20, in the year 2014.

The application rates of limestone are presented in Figures 7 and 8. The use of variable rate for pH control is very important and in turn already provides Ca and Mg in the application, acting in a buffering way, balancing this acidity. Ca ion is associated with high dry matter yield, with its fundamental performance in root formation (Roque et al., 2004), being Mg, an indispensable ion in the photosynthetic process, acting as an enzymatic activator in carbohydrate metabolism and nucleic acid synthesis (Reis; Chepote, 2008; Santos, 2015).

Acoording Blum & Lasaga (1988), the role of pH in the dissolution of minerals is related to the adsorption of H^+ and OH^- ions on mineral surfaces, in which hydrolysis is controlled by acid-base reactions and oxygen.

It can be observed that in the year 2013, 6.09 hectares had pH close to 8, which could compromise the productivity of the rubber tree. With the use of variable rate treatment, the pH values approached the range closest to the ideal one, causing a gain in productivity. In the work of Zaninetti et al., (2006), with rubber trees from 6 years to 45 years in the Amazon showed a pH of 4.09, which differed from this work with the lowest pH content of 4.5.

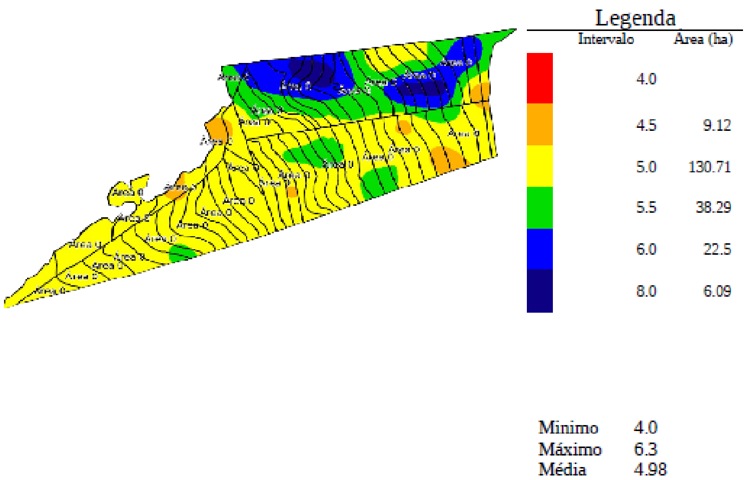

Figure 7. Map representing the distribution of the pH content in depth 0-20 in the year 2013.

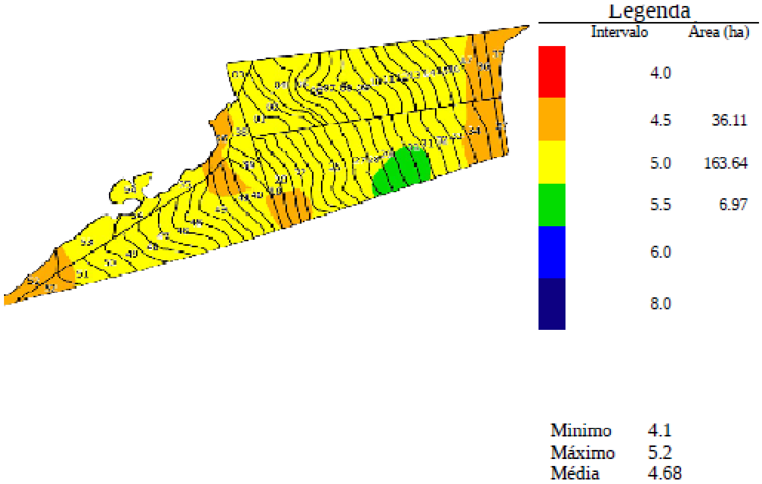

Figure 8. Map representing the distribution of the pH content in the depth of 0-20, in the year 2014

Figures 9 and 10 show the limestone rates recommended for the years 2013 and 2014 respectively. It was possible to analyze the differences of recommendations between the two evaluated years, where in 2013, 190.57 ha, there was a need to apply 1500 kg/ha of limestone, 7.66 ha of the recommendation was 2000 kg/ha, in some parts 8,48 there is a need for the application of 2,500 kg/ha of limestone; in 2014 it was observed that there is a need for a correction greater than in relation to 2013, where limestone recommendation levels of 1500 kg/ha were recommended for 178.3 ha of the total area, and 7.66 ha with the recommendation of 2000 kg/ha being 8.48 ha with the recommendation of 2500 kg/ha of limestone, the most significant difference of 2014 in relation to 2013 was the uniformity of the recommendations where in 2013 there were circular bores in the area with the recommendation of 2000 kg/ha, where in 2014 it was possible to observe that they were corrected. However, in the recommendation of the total distribution of the area in 2014 hears a need for application of 159.34 t, already in 2013, the total amount of product in the area was 146.14 t of limestone.

Acoording Virgens Filho et al. (2001), the leaf contents of N, P, S, Cu and Zn were affected by absence of liming and fertilization, and K, Ca, Mg, B, Fe and M did not present significant differences. In addition, according to Carvalho et al., (2011) soil acidity negatively affects root system and crop growth.

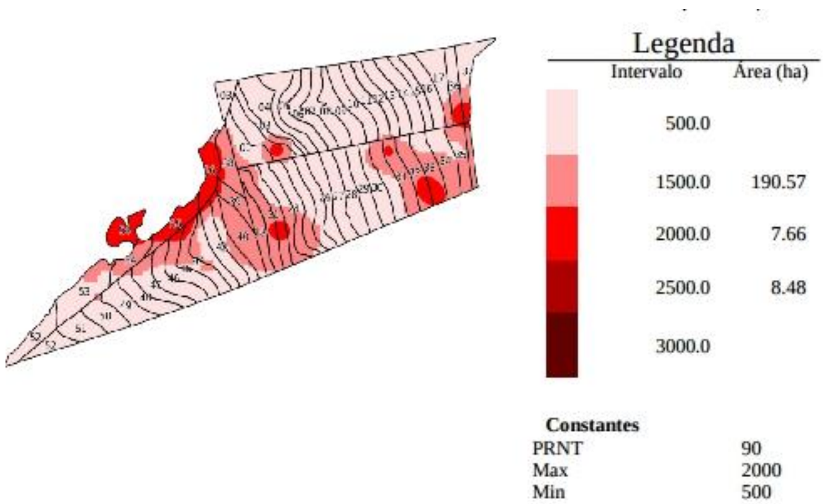

Figure 9. Map representing the distribution of the limestone recommendation at depth of 0-20, in the year 2013.

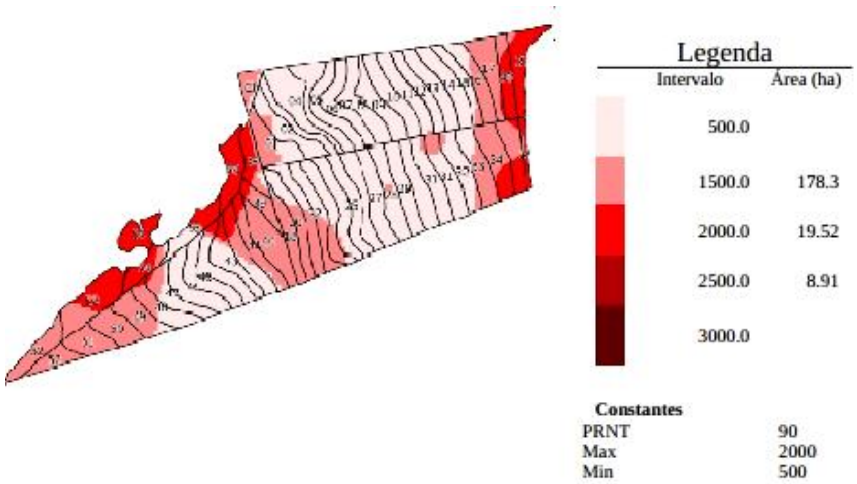

Figure 10. Map representing the distribution of the limestone recommendation at depth of 0-20, in the year 2014**.**

It can be observed an increase in the dose, showing that the doses applied in fixed rate were being inferior to those considered ideal, and consequently impairing the absorption of nutrients and response in productivity.

It is also necessary to observe that the applied technology had to be adapted to the reality of the fitness of the segment of the rubber tree, where it was only corrected by the average, and after the work was considered the spatial variability of the soil, also the area was divided in a board taking advantage of the divisions of tasks, linking the management information to the processes, allowing results to be obtained by tasks, which in turn makes it possible to estimate the cost of the management by task, and the behavior of clones in relation to soil type, correction, and treatments by tasks.

According to the application in ATV, application savings were observed, as presented in Table 2.

Activity	Return
Limestone Reduction with ATV	61.10 tons
Cost reduction in Brazilian real	R$ 1,833.01 real
It corresponds to the amount of dry	780 kg in GEB – BR sold to 2.35 reais /kg
Corresponds to the annual production per	91.1 trees/year

Table 2. Comparison of cost reduction with application of limestone.

With the obtained results of saving of application of correctives, it was verified the reduction in the application of the order of 61,1 tons in the area where the study was carried out. This reduction implied in the economy, for acquisition, approximately, R$ 1,833.01. This economy is even greater if we take into account the lower expenses with the distribution of correctives (labor, fuel, equipment wear) and freight. This reduction corresponds to the increase of 91.1 trees harvested in the area per year. For Franchin et al., (2009), the application by variable rate resulted in a saving of 5.68% in relation to the application by management zones.

Weirich Neto et al., (2006) observed an economy of 7.84 t of limestone in an area of 9.6 ha in relation to the conventional system. Ragagnin et al., (2010) observed that the amount of limestone needed was higher than if the variable rate was used in relation to the conventional system when using sampling points.

It can be observed that if a work with the use of technology in 18 tasks was obtained and a cost reduction of 780 kg of dry rubber that would be used to pay costs, in 56 tasks (total area of the studied field) would be possible the economy of 2,426 kg dry rubber, that is, the annual output of 285 trees with the average annual output of 8.5 kg/year. And if added to the production gain, logistics, manpower, this can increase the average economy, this management vision in a rubber plant established to produce on average 50 years, and of fundamental importance, since with adequate management both agronomic and administratively generates profit, production, economy, enabling the producer to return this money that was saved, in the rubber tree itself.

CONCLUSIONS

The use of the technology of application in varied rate provided the necessary supply for the full development and production of the rubber tree.

The planning of correctives and inputs according to the recommended for each task provided a reduction in the costs of the property: cost of acquisition, distribution and manpower.

The environmental impacts caused when using fixed rates are, in most cases, greater than those charged at a variable rate.

The amount of dry rubber increases production when application is applied in varied rate due to the application of adequate amount of exchangeable Ca.

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